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Offsets and prioritizing the selection of new elements in search displays: More evidence for attentional capture in the preview effect

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The preview effect refers to the finding that new elements in a search display are prioritized over old elements. Donk and Theeuwes (2001) suggest that this prioritization is due to bottom-up attentional capture, as new elements that abruptly appear with increases in luminance produce a preview effect whereas new elements that are equiluminant to the background do not. The present study extends this research by examining if new elements that appear from offsets, with and without luminance changes, yield similar findings to onsets. This was indeed the case, as equiluminant offsets did not produce a preview effect but offsets with corresponding increases or decreases in luminance did show the prioritization of new elements over old elements. These findings show that the prioritization of new elements is sensitive to changes in luminance but not to the direction of such changes.

People tend to attend to the new and ignore the old. This is not only true for auditory or tactile perception but also for visual perception. That is, people preferentially select objects that just appeared in the visual field at the expense of objects that are already present in the visual field. Early evidence for prioritized selection of new over old objects was provided by Kahneman, Treisman, and Burkell (1983), who demonstrated a reduced distractor interference effect when distractors were displayed prior to the appearance of an imperative stimulus. More recently, Watson and Humphreys (1997)

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found that people can also prioritize the selection of new items in a visual search task. Instead of using the typical visual search procedure in which all of the visual search items are presented simultaneously, they conducted a series of experiments in which half of the items (*old*) appeared before the other half of the items (*new*). Importantly, the target always appeared in the new item display and never in the old item display. The general finding from these experiments was that people were able to limit their search to the new items only while effectively ignoring the old items. The basic effect has become known as the *preview effect*, a term reflecting the finding that people are able to prioritize the selection of new items over old items in visual search. To explain the preview effect, Watson and Humphreys proposed the mechanism of *visual marking*, in which a top-down process would apply inhibitory tags to the old items, thus deprioritizing those items for selection (see also Kunar, Humphreys, & Smith, 2003; Theeuwes, Kramer, & Atchley, 1998; Watson & Humphreys, 2000).

Since the visual marking account, at least two alternative explanations have been put forward: The temporal segregation account (Jiang, Chun, & Marks, 2002), and the attentional capture account (Donk & Theeuwes, 2001).

According to the temporal segregation account, new elements are prioritized over old ones because new and old elements can be segregated into two perceptual groups due to their temporal asynchrony (Jiang et al., 2002). Subsequently, attention can selectively enhance the processing of one group over the other. Even though the temporal segregation account of prioritized selection was put forward as an alternative to the visual marking account, it also bears some resemblance to the prior theory. Most importantly, according to the temporal segregation hypothesis, prioritized selection is assumed to be based on a top-down process.

Another alternative explanation for the preview effect has been proposed by Donk and Theeuwes (2001). Their explanation is based on several studies that have shown that abrupt onsets tend to automatically capture attention (e.g., Theeuwes, 1991; Yantis & Jonides, 1984). Essentially, Donk and Theeuwes noted that both old and new items appear as abrupt onsets; thus, attention will first be captured by the old items and then by the new items. Since that target appears with the new items, attention will be allocated to the new items in the display when the search for the target is initiated, resulting in the selection of new items over old items. To substantiate their account, Donk and Theeuwes compared searches in which items appeared with, or without, luminance changes. They found that when both new and old items appeared equiluminant to the background there was no preview effect. However, when only the old items were equiluminant, with the new items appearing with an increase in luminance from the background, a preview effect was found. From these findings, Donk and Theeuwes concluded that the mechanism underlying the preview effect is the bottom-up capture of attention by salient events in the visual field (see also Donk & Theeuwes, 2003; Donk & Verburg, 2004).

The purpose of the present study is to determine if other dynamic visual events will yield that same pattern of results as that found by Donk and Theeuwes (2001). In other words, is the mechanism underlying the preview effect due to attentional capture in general (i.e., any salient visual event is sufficient to produce a preview effect) or is the preview event limited to when attention is captured by abrupt onsets? Although Donk and colleagues clearly discuss the underlying mechanism in terms of attentional capture in general, all of their experiments showing preview effects have only used abrupt onset stimuli (Donk & Theeuwes, 2001, 2003; Donk & Verburg, 2004).

To examine the generality of the attentional capture explanation for the preview effect, the present study will use abrupt offsets in a preview paradigm. The main reason for this is that offsets are as ubiquitous as onsets; almost every time we shift our gaze, various objects suddenly appear in the visual field and other objects suddenly disappear. Moreover, there is evidence from other paradigms that the abrupt disappearance of stimuli produces many of the same attentional effects associated with onsets. For example, using an attentional cueing paradigm, Pratt and McAuliffe (2001) found onsets and offsets produced equivalent facilitation effects at short cue–target intervals and equivalent inhibition of return effects at long cue–target intervals (see also Theeuwes, 1991). Thus, there is reason to think that offsets should produce preview effects in much the same way as onsets do.

There is, however, also evidence suggesting that offsets do not function in entirely the same manner as onsets. In particular, there are some studies that show that offsets produce weaker attentional capture than do onset stimuli. Boot, Kramer, and Peterson (2005) found that saccades were much more likely to be made to onset distractors than offset distractors. Similarly, incorrect prosaccades in an antisaccade task are much more likely to be made in response to onset distractors than to offset distractors (Pratt & Trottier, 2005). Finally, Brockmole and Henderson (2005), using real-world scenes, found that onsets routinely captured attention, even in the absence of transients (i.e., when the onset occurred during a saccade). Offsets, however, only captured attention when salient transients occurred or if the offset object was occluding another object. One likely reason why offsets are less successful in capturing attention is that while both onsets and offsets produce salient luminance changes in the visual field, onsets may have the additional attention capturing effect associated with the appearance of new objects (e.g., Yantis & Hillstrom, 1994). It is worth noting that capture likely has some upper boundary, depending on the paradigm, and luminance and object appearance may not be simply additive.

As noted earlier, the main purpose of this study is to determine whether or not the attentional capture explanation for the preview effect proposed by Donk and Theeuwes (2001) can be extended beyond abrupt onsets to other types of dynamic event. To do so, two specific research questions will be addressed. The first question concerns whether or not offset stimuli are capable of capturing attention and producing preview effects. This will be examined with two types of offset stimuli: One where the offset produces an increase in luminance and one that produces a decrease in luminance (Experiments 1 and 2, respectively). The second question concerns the key finding from Donk and Theeuwes: Will equiluminant offset stimuli fail to produce a preview effect (Experiment 3)?

EXPERIMENT 1

The first experiment was designed to determine if preview effects can be found with abruptly offsetting stimuli. To do so, one major modification to the typical preview effect paradigm is necessary. Because something has to be visible in the display to be subsequently removed, unlike the blank visual displays initially presented in most preview effect studies, the initial display here consists of 100 placeholders organized into a 10×10 grid. Portions of the placeholders will then be removed to reveal the old and new items. In previous preview effect studies, the abrupt onsets of the stimuli were signalled by both increases in luminance and the appearance of new objects. Given that previous work has shown that the attentional capture that produces the preview effect relies on increases in luminance and not the appearance of new objects (if this was not the case, preview effects should be easily found in equiluminant displays), in the present experiment portions of black placeholders were removed to reveal the higher luminance background. Thus, the offsets in this experiment were signalled by the disappearance of portions of objects with corresponding increases in luminance. If the capture of attention by an increase in luminance is sufficient to produce a preview effect, the response times (RTs) to the find the target in the new display should be unaffected by the number of items in the old display. Conversely, if offset stimuli, regardless of the increase in luminance, are insufficient to capture attention, then RTs should be influenced by the number of old items.

Methods

Subjects. Twelve undergraduate students from the University of Toronto participated in the experiment in exchange for course credit. The subjects had corrected or correct-to-normal vision and were naïve to the purpose of the study.

Apparatus and procedure. The experiment was conducted on a PC computer with CRT monitor in a dimly lit, sound attenuated room. Viewing distance was held constant at 44 cm with a chin/headrest.

A schematic of a typical trial sequence is shown in Figure 1. Each trial began with an initial display consisting of 100 placeholders (in a 10×10 grid). The placeholders, overlapping "8"s and "X"s in LCDMono (0.75° high, 0.50° wide, 1.0° centre-to-centre distance between placeholders), were drawn in black (RGB 0,0,0; 0 cd/m^2) against a green background (RGB 0,150,0; 25.4 cd/m^2). In addition, there was a small black plus sign in the centre of the grid of placeholders, and subjects were asked to fixate on this item (fixation was checked with closed circuit video). After 1500 ms had elapsed, the old items were then revealed by removing 2, 6, or 12 "8"s or "X"s from the displayed placeholders (thus revealing "X"s or "8"s, respectively). Following a delay of 1000 ms, the new items were presented by removing another 1, 5, or 11 "8"s or "X"s from the remaining placeholders and also replacing one additional placeholder with a single "L" or "J". Subjects were instructed to determine whether an "L" (press "z"

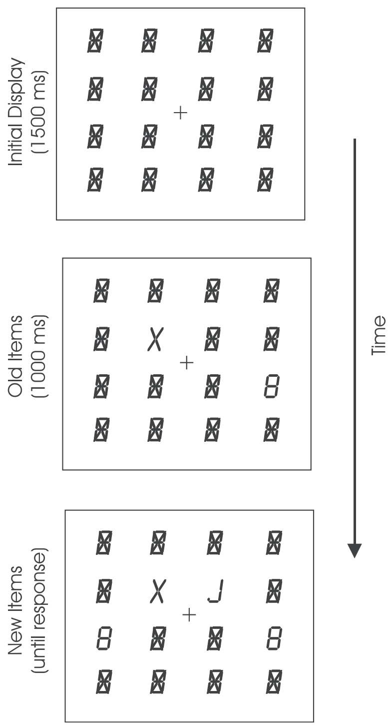

Figure 1. A schematic of a typical trial sequence with 2 old items and 2 new items (1 distractor and 1 target). For simplicity, a 4×4 grid is shown instead of the 10×10 grid used in the study.

key with left hand) or a "J" (press "/" key with right hand) was present when the new items were revealed. If no response was made after 3000 ms, an error tone was sounded and the next trial was started. Error tones also occurred if a RT was less than 100 ms or if the wrong key was pressed. The intertrial interval was 1000 ms.

Design. Each of the subjects completed 300 trials. Across these trials, it was randomly determined which one of the three set sizes of old items and new items would appear, and that the target would be an "L" or a "J". In addition, it was randomly determined which placeholders would become distractors, and whether each distractor would be "8" or an "X". The target location was also randomized, although the target could not occur at a distractor location. Short breaks were given every 100 trials.

Results and discussion

The mean RTs are presented in the top panel ("Increase") of Figure 2, and were analysed with a 3 (old items: 2, 6, 12) $\times$ 3 (new items: 2, 6, 12) analysis of variance (ANOVA). Only a main effect of new items was found, $F(2, 22) = 9.6$, $MSe = 6400$, $p < .001$, with longer RTs as the number of new item distractors increased. Importantly, neither the old item main effect, $F(2, 22) < 1.1$, $MSe = 9005$, $p > .34$, nor the interaction of old and new items, $F(4, 44) < 1$, $MSe = 3167$, reached significance.

The slopes and intercepts appear in Table 1 and the mean error rates appear in Table 2. Error rates were analysed using two separate 3 (old items) $\times$ 3 (new items) ANOVAs as in the RT analysis. Neither main effect, Fs (2, 22) < 1.1, ps $> .30$, nor the interaction, $F(4, 44) < 1.5$, $p > .20$, reached significance.

The finding that the old items did not affect RTs indicate that preview effects can be found with the offset stimuli used in the present experiment. Thus, it appears that increases in luminance, regardless of how those changes in brightness are instantiated, can capture attention and produce preview effects.

EXPERIMENT 2

The results of the previous experiment, and those from Donk and Theeuwes (2001, 2003) and Donk and Verburg (2004), provide ample evidence that increases in luminance, not simply the appearance of new objects in the visual field, underlie the preview effect. What is not known is if changes in luminance of the same magnitude, but in the opposite direction, will also produce preview effects. In other words, is the attentional explanation of Donk and Theeuwes limited to increases in luminance or does it also apply

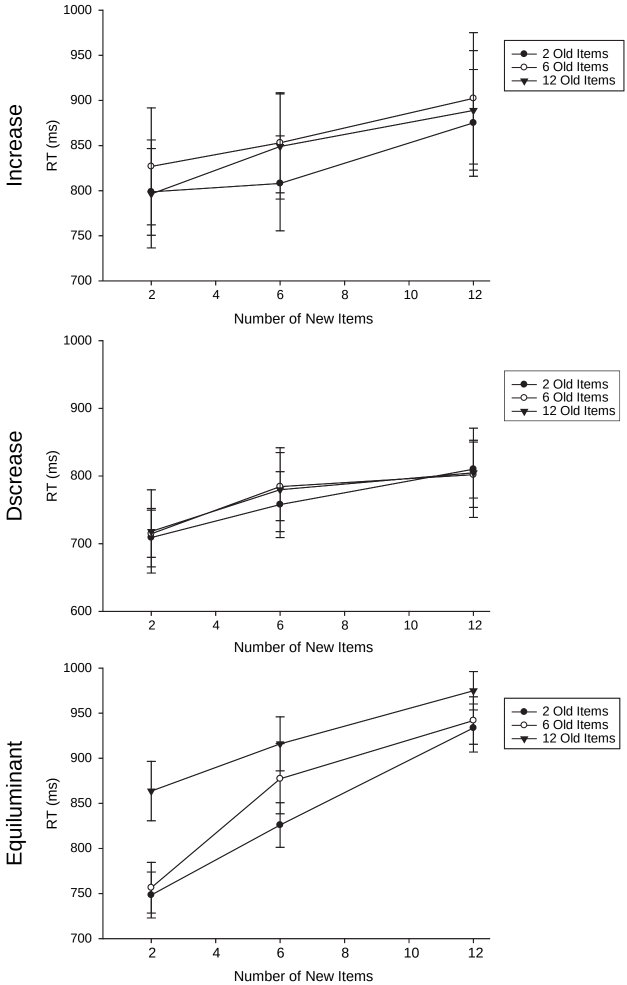

Figure 2. Mean RTs for the luminance increase (Experiment 1), luminance decrease (Experiment 2), and equiluminant (Experiment 3) offset conditions. The number of new items includes the distractors and the target. Error bars are standard error.

to decreases in luminance? Indeed, if the preview effect reflects the operation of luminance-driven attentional capture, such capture should occur regardless the dynamic changes in luminance are increases or decreases, as has been found in other attentional capture paradigms (e.g., Pratt & McAuliffe, 2001). Thus, while the preview effect does not appear to rely on only the appearance of new objects, the question remains as to whether or not it is limited to increases in luminance. To address this question, the present experiment uses

TABLE 1
Slopes and intercepts for Experiment 1 (luminance increase), Experiment 2 (luminance decrease), and Experiment 3 (equiluminance)

	Experiment 1	*Experiment 2*	*Experiment 3*
Slope			
New items	15.8	8.86	8.19
Old items	6.6	3.9	2.4
Intercept			
New items	765	705	789
Old items	776	706	822

the same paradigm as Experiment 1 but now removes portions of high luminance items on a black background so that new items have corresponding decreases in luminance.

Methods

Subjects. Twelve undergraduate students from the University of Toronto participated in the experiment in exchange for course credit. The subjects had corrected or correct-to-normal vision, had not participated in the previous experiment, and were naïve to the purpose of the study.

Apparatus, procedure, and design. The apparatus, procedure, and design are the same as used in Experiment 1 except that now the placeholders were drawn in green against a black background.

Results and discussion

The mean RTs are in the middle panel ("Decrease") of Figure 2, and were analysed with a 3 (old items: 2, 6, 12) $\times$ 3 (new items: 2, 6, 12) ANOVA. Only

TABLE 2
Percentage errors for Experiment 1 (luminance increase), Experiment 2 (luminance decrease), and Experiment 3 (equiluminance)

	Old items								
	2			*6*			*12*		
New items	*2*	*6*	*12*	*2*	*6*	*12*	*2*	*6*	*12*
Experiment 1	1.8	2.0	1.5	2.1	1.8	1.9	1.9	2.3	2.1
Experiment 2	2.4	2.2	0.9	2.4	2.2	1.9	1.4	2.6	1.2
Experiment 3	2.8	6.7	4.2	3.1	6.3	6.3	4.9	3.4	3.9

a main effect of new items was found, $F(2, 22) = 26.9$, $MSe = 2897$, $p < .001$, with longer RTs as the number of new item distractors increased. Importantly, neither the old item main effect, $F(2, 22) < 1$, $MSe = 3474$, nor the interaction of old and new items, $F(4, 44) < 1$, $MSe = 1793$, reached significance.

The slopes and intercepts appear in Table 1 and the mean error rates appear in Table 2. Error rates were analysed using two separate 3 (old items) $\times$ 3 (new items) ANOVAs as in the RT analysis. Neither main effect, Fs (2, 22) < 1.6, ps $> .25$, nor the interaction, $F(4, 44) < 1$, reached significance.

The findings from the present experiment show that offset stimuli with corresponding decreases in luminance, like the increases previously examined, are capable of producing preview effects. Taken together, the first two experiments provide two major pieces of information: (1) The preview effect is not limited to only onset stimuli, and (2) a salient change in luminance, regardless of the direction, can produce preview effects.

EXPERIMENT 3

Having established that both increases and decreases in luminance associated with offset stimuli can produce preview effects, it is important to test the condition that provides the key piece of evidence for Donk and Theeuwes's (2001) attentional capture explanation—equiluminant stimuli. If offset stimuli function in essentially the same way as onset stimuli in the preview effect, no such effect should be found when portions of the placeholders are removed to reveal an equiluminant background.

Methods

Subjects. Twelve undergraduate students from the University of Toronto participated in the experiment in exchange for course credit. The subjects had corrected or correct-to-normal vision, had not participated in the previous two experiments, and were naïve to the purpose of the study.

Apparatus, procedure, and design. The apparatus, procedure, and design are the same as used in Experiment 1 except that now the placeholders were drawn in green against a grey background. The grey background luminance was determined for each subject by a short pretest using the method of adjustment (i.e., comparing grey luminance to the green luminance used previously, 25.4 cd/m^2).

Results and discussion

The mean RTs are presented in the bottom panel ("Equiluminant") of Figure 2, and were analysed with a 3 (old items: 2, 6, 12) × 3 (new items: 2, 6, 12) ANOVA. As before, a main effect was found for the new items, $F(2, 22) = 34.8$, $MSe = 6659$, $p < .001$, with longer RTs as the number of new item distractors increased. Unlike the previous two experiments, a old item main effect was also found, $F(2, 22) = 7.9$, $MSe = 8186$, $p < .003$, with longer RTs as the number of new item distractors increased. The interaction was also significant, $F(4, 44) = 3.0$, $MSe = 2458$, $p < .03$, as the influence of the old items decreased as the number of new items increased.

The slopes and intercepts appear in Table 1 and the mean error rates appear in Table 2. Error rates were analysed using two separate 3 (old items) × 3 (new items) ANOVAs as in the RT analysis. Neither the main effect of old items, $F(2, 22) < 1.8$, ps $> .20$, nor the interaction, $F(4, 44) < 1$, reached significance.

In addition to the analysis of the equiluminant data, a 3 (old items) × 3 (new items) × 3 (Experiment) ANOVA was conducted on the mean RTs. Main effects were found for old items, $F(2, 66) = 4.8$, $MSe = 4446$, $p < .015$, and new items, $F(2, 66) = 62.8$, $MSe = 5318$, $p < .001$, but not for experiment, $F(2, 33) < 1$, $MSe = 525515$. An interaction was found between old and new items, $F(4, 132) = 3.1$, $MSe = 3694$, $p < .02$, and experiment also interacted with new items, $F(4, 66) = 3.5$, $Mse = 5318$, $p < .015$. Even though a trend toward an interaction was found between experiment and old item, $F(4, 66) = 2.3$, $MSe = 4446$, $p < .070$, the three-way interaction of experiment by old items by new items was significant, $F(8, 132) = 2.1$, $MSe = 3694$, $p < .04$, as the pattern of RTs found in Experiment 3 (no preview effect) was different from the patterns found in Experiments 1 and 2 (preview effects).

Similar to the findings of Donk and Theeuwes (2001), when there was no change in luminance associated with the offset presentation of the old and new items, no preview effect was found. The interaction between old and new elements does, however, suggest that large discrepancies between the number of old and new elements may affect visual search times. When looking at the equal set sizes (2 old–2 new, 6 old–6 new, 12 old–12 new) in Figure 2, the effect of the number of old elements (i.e., no preview effect) is clear. Overall, the results of the present experiment support the notion that onset and offset stimuli function in similar manners in preview effect paradigms. Moreover, the key to whether or not a preview effect will be found appears to be whether or not there is a change in luminance, not whether or not visual information appears or disappears.

GENERAL DISCUSSION

The three experiments that comprise this study provide converging evidence that offset stimuli produce preview effects in much the same way as onset stimuli; preview effects are present when there are changes in luminance but not when the stimuli are equiluminant with the background. In other words, offsets appear to be sufficient to produce the capture needed for preview effects. This conclusion is consistent with the reports from various attentional capture paradigms, although several of these studies also indicated that capture may not be as strong with offsets than for onsets (e.g., Boot et al., 2005; Brockmole & Henderson, 2005; Pratt & Trottier, 2005). Thus, preview effects may not reflect that magnitude of attentional capture but rather if capture occurred at all. Indeed, it is possible that the capture generated by offsets lies toward the minimum for producing preview effects while onsets generate levels of capture well beyond any preview effect threshold.

The present study highlights the importance of luminance changes in the prioritization of new over old elements. Taken in conjunction with Donk & Theeuwes (2001), it is clear that it is the presence of a luminance change, not the direction of the change, that produces a preview effect in visual search. Thus, although Donk and Theeuwes (see also Donk & Theeuwes, 2003; Donk & Verburg, 2004) noted the special role of abrupt onsets in the preview effect, the capture of attention in visual search is not restricted to the sudden appearance on new items. Rather, attention in visual search is captured by local changes in luminance, regardless of whether that change is produced by an abrupt increase or decrease in local luminance. Such a direction-independent change detector is well-suited for the production of very rapid shifts of attention to a wide range of dynamic events in the visual field. In other words, such a direction-independent change detector provides for the fastest deployment of attention, across the broadest range of visual events; a very useful mechanism when faced with planning and producing actions in very complex visual environments.

The present results cannot easily be accommodated by a visual marking account. According to Watson and Humphreys (1997), observers are able to selectively inhibit the locations of the old items in anticipation of the new items to be presented (see also Humphreys, Jung-Stalmann, & Olivers, 2004; Kunar et al., 2003; Watson and Humphreys, 1997, 2000). In the present experiment, old items were simultaneously presented with placeholders, some of which changed into new items after the preview period elapsed. If observers would have actively inhibited the locations of the old (letter) items only, the required number of elements to be searched through would have been 100 (the total number of placeholders and items) minus the number of old items. The average values of the RTs makes this possibility highly unlikely. Alternatively, if observers would have inhibited all locations, i.e., those containing old items and those containing placeholders, target search would have been impossible due to the fact that the target appeared on a location previously occupied by a placeholder.

The present findings also challenge the temporal segregation hypothesis of Jiang et al. (2002). Jiang et al. proposed that (part of) the preview effect is the result of the ability of observers to group subsets of elements on the basis of their temporal separation. They assume that the preview effect occurs because after segregation of the old and new elements, attention may be selectively deployed to the group that contains the target. The present study shows that irrespective of the temporal separation between the appearance of the old and new items, prioritized selection is critically dependent on whether or not new items were presented with luminance change.

Although the present findings demonstrate the importance of luminance changes, these data do not allow the conclusion that preview effects rely solely on new elements to occur with increases or decreases in luminance. For example, if old and new elements differ from each other on a basic feature dimension (e.g., when the old elements are green and the new elements are blue), it is possible that luminance change is no longer necessary for prioritized selection of new elements. Indeed, recently, Braithwaite, Humphreys, Watson, and Hulleman (2005) demonstrated that prioritized selection for new elements can also occur in the absence of luminance changes. However, in contrast to the present study, the old and new items they presented differed in luminance relative to each other. Due to the presence of a luminance difference between old and new items, observers might have used a prioritization mechanism different from a mechanism that is based on onset capture. Subset selective search with subsets differing in a basic feature dimension might be mediated by multiple mechanisms including visual marking, feature inhibition mechanisms, and feature anticipation mechanisms (e.g., Braithwaite & Humphreys, 2003; Egeth, Virzi, & Garbart, 1984; Kaptein, Theeuwes, & van der Heijden, 1995). When feature differences between old and new items are abolished, prioritized selection only occurs when the presentation of new items is accompanied by a luminance change. The results of the present study show that if new elements appear from offsets, the results are similar to those with new elements that appear from onsets.

It should also be noted that that while the present work is consistent with the attention capture account of the preview effect, the centrepiece of this account has not gone unchallenged. In particular, two recent studies provide evidence that it is possible to obtain preview effects with isoluminant items; the previously discussed Braithwaite et al. (2005) and the more recent Braithwaite, Hulleman, Watson, and Humphreys (2006). In the later paper, Braithwaite et al. (2006) used equiluminant elements and found no preview effect with a 1000 ms preview duration but discovered that the preview effect emerged with a 3000 ms preview duration. From these data, they suggest that visual marking takes longer to emerge with equiluminant elements because the location coding (of the old elements) may be less efficient. Even though the explanation of Braithwaite et al. (2006) is feasible for their results, it is difficult to reconcile with previous findings. For example, Donk and Theeuwes (2001), found preview effects at 1000 ms preview durations when old elements were equiluminant but new elements were not. Moreover, Donk and Verburg (2004) demonstrated that prioritized selection of new elements can even be achieved with 50 ms previews as long as old (but not new) elements are isoluminant with the background. Thus, isoluminance of old elements does not per se result in any difficulties to prioritize the new elements. Instead, the luminance of the new elements appears to be critical in determining the presence of a preview effect. The absence of a preview benefit in the 1000 ms preview duration condition and the presence of a preview benefit in the 3000 ms preview duration condition in Braithwaite et al. (2006) are therefore not necessarily related to the efficiency of location coding (of the old elements). Instead, the longer preview duration may have enabled observers to better remember the locations of the old elements as being irrelevant. It is also possible that the long preview durations may have allowed subjects to sequentially fixate the old items during the preview with the result that these items did not compete for attentional resources upon the presentation of the new (isoluminant) items.

The finding of a strong preview effect with luminance offsets is consistent with several earlier reports that offsets function very much like onsets in a variety of attentional tasks (e.g., Pratt & Hirshhorn, 2003; Pratt & McAuliffe, 2001; Theeuwes, 1991). However, both Boot et al. (2005), and Brockmole and Henderson (2005), have recently presented evidence that offsets may be less able to capture attention than onsets. It is important to note, though, that their methods were quite different from those used in the present study. For example, Boot et al. used predictive onsets and offsets which served as pro- or anticues. Brockmole and Henderson presented objects during fixation or saccades in real-life scenes. Such manipulations may be especially sensitive to smaller gradations of capture. The preview effect, on the other hand, may be relatively insensitive to such gradations; if a sufficient level of capture is reached, a preview effect occurs. If a sufficient level of capture is not reached, the new items are not prioritized and no preview effect is found. Thus, the key feature of the preview effect may be whether or not attention is captured (to some threshold level), and in this regard, offsets appear to function as effectively as onsets.

The present results also bear some resemblance to those earlier obtained by Peterson, Belopolsky, and Kramer (2003). In their Experiment 1, participants performed a preview task and had to indicate whether a target Z or a reverse Z was present. Both old and new elements were presented with luminance onset (Experiment 1A), without luminance onset (Experiment 1B), or with luminance offset (Experiment 1C). When elements were presented with luminance offset, previously presented grey stimulus placeholders were offset and replaced with green letter stimuli. The results demonstrated a preview effect when elements were presented with luminance onset but not when elements were presented without luminance onset. More important in the present context was their finding that new elements were also prioritized when elements were revealed by the offset of previously presented placeholders. Peterson et al. concluded that the preview benefit might occur for different visual transients and is not limited to rapid luminance onsets. They hypothesized that prioritized selection of visual transients is mediated by the magnocellular system.

Even though Peterson et al. (2003) showed a preview effect with offsetting elements, they did not unequivocally demonstrate that this preview effect was *caused* by the luminance offsets of the new elements. Peterson et al. presented only a limited number of placeholders. As a result, these placeholders could have acted as cues during the preview as to where the new elements would appear. In the present study, the number of placeholders greatly exceeds the number of elements, preventing participants from using the placeholders as cues for the locations of the new elements. Moreover, in the present study the effect of the number of old elements in the offset condition could be directly compared to the effect of the number of old elements in the no-offset condition. If preview effects would have been caused by the placeholders acting as location cues as to where the new items would appear, this effect should have occurred both in the offset and in the no-offset condition. The results showed that this was not the case.

Concluding, the present study represents the first study demonstrating that new elements can be fully prioritized when they are presented with offset as long as the offsets are accompanied by luminance change. When new elements are presented without luminance change, no prioritized selection occurs. These results strongly suggest that prioritized selection of new over old elements is mediated by the magnocellular visual system, which is sensitive to rapid luminance changes.

REFERENCES

Boot, W. R., Kramer, A. F., & Peterson, M. S. (2005). Oculomotor consequences of abrupt onsets and offsets: Onsets dominate oculmotor capture. *Perception and Psychophysics*, *67*, 910–928.

Braithwaite, J. J., Hulleman, J., Watson, D. G., & Humphreys, G. W. (2006). Is it impossible to inhibit isoluminant items, or does it simply take longer? Evidence from preview search. *Perception and Psychophysics*, *68*, 290–300.

Braithwaite, J. J., & Humphreys, G. W. (2003). Inhibition and anticipation in visual search: Evidence from effects of color foreknowledge on preview effect. *Perception and Psychophysics*, *65*, 213–237.

Braithwaite, J. J., Humphreys, G. W., Watson, D. G., & Hulleman, J. (2005). Revisiting preview search at isoluminance: New onsets are not necessary for the preview advantage. *Perception and Psychophysics*, *67*, 1214–1228.

Brockmole, J. R., & Henderson, J. M. (2005). Object appearance, disappearance, and attention prioritization in real-world scenes. *Psychonomic Bulletin and Review*, *12*, 1061–1067.

Donk, M., & Theeuwes, J. (2001). Visual marking beside the mark: Prioritizing selection by abrupt onsets. *Perception and Psychophysics*, *62*, 891–900.

Donk, M., & Theeuwes, J. (2003). Prioritizing selection of new elements: Bottom-up versus top-down control. *Perception and Psychophysics*, *65*, 1221–1242.

Donk, M., & Verburg, R. C. (2004). Prioritizing new elements with a brief preview period: Evidence against visual marking. *Psychonomic Bulletin and Review*, *11*, 282–288.

Egeth, H. E., Virzi, R. A., & Garbart, H. (1984). Searching for conjunctively defined targets. *Journal of Experimental Psychology: Human Perception and Performance*, *10*, 32–39.

Humphreys, G. W., Jung-Stalmann, B., & Olivers, C. N. L. (2004). An analysis of the time-course of attention in preview search. *Perception and Psychophysics*, *66*, 713–730.

Jiang, Y., Chun, M. M., & Marks, L. (2002). Visual marking: Selective attention to asynchronous temporal groups. *Journal of Experimental Psychology: Human Perception and Performance*, *28*, 717–730.

Kahneman, D., Treisman, A., & Burkell, J. (1983). The cost of visual filtering. *Journal of Experimental Psychology: Human Perception and Performance*, *9*, 510–522.

Kaptein, N. A., Theeuwes, J., & van der Heijden, A. H. C. (1995). Search for a conjunctively defined target can be selectively limited to a color-defined subset of elements. *Journal of Experimental Psychology: Human Perception and Performance*, *21*, 1053–1069.

Kunar, M. A., Humphreys, G. W., & Smith, K. J. (2003). History matters: The preview benefit in search is not onset capture. *Psychological Science*, *14*, 181–185.

Peterson, M. S., Belopolsky, A. V., & Kramer, A. F. (2003). Contingent visual marking by transients. *Perception and Psychophysics*, *65*, 695–710.

Pratt, J., & Hirshhorn, M. (2003). Examining the time course of facilitation and inhibition with simultaneous onset and offset cues. *Psychological Research/Psychologische Forschung*, *67*, 261–265.

Pratt, J., & McAuliffe, J. (2001). The effects of onsets and offsets on visual attention. *Psychological Research/Psychologische Forschung*, *65*, 185–191.

Pratt, J., & Trottier, L. (2005). Pro-saccades and anti-saccades to onset and offset targets. *Vision Research*, *45*, 765–774.

Theeuwes, J. (1991). Exogenous and endogenous control of attention: The effect of visual onsets and offsets. *Perception and Psychophysics*, *49*, 83–90.

Theeuwes, J., Kramer, A. F., & Atchley, P. (1998). Visual marking of old objects. *Psychonomic Bulletin and Review*, *5*, 130–134.

Watson, D. G., & Humphreys, G. W. (1997). Vision marking: Prioritizing selection for new objects by top-down attention inhibition of old objects. *Psychological Review*, *104*, 90–122.

Watson, D. G., & Humphreys, G. W. (2000). Vision marking: Evidence for inhibition using a probe-dot detection paradigm. *Perception and Psychophysics*, *62*, 471–481.

Yantis, S., & Hillstrom, A. P. (1994). Stimulus-driven attentional capture: Evidence from equiluminant visual objects. *Journal of Experimental Psychology: Human Perception and Performance*, *20*, 95–107.

Yantis, S., & Jonides, J. (1984). Abrupt visual onsets and selective attention: Evidence from visual search. *Journal of Experimental Psychology: Human Perception and Performance*, *10*, 601–621.

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